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# COMBAT SYNTHETIC TRAINING ASSESSMENT RANGE (CSTAR)

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The purpose of Combat Synthetic Training Assessment Range (CSTAR) is to create a collective training system designed to enhance integrated combined arms training for brigades in garrison and at the Combat Training Centers (CTC). Its primary purpose is the development and evaluation of battle command capabilities that accrue from organizational and technological changes at the brigade level that: 1. Increase battle space (time, scope, and resolution); 2. Promote the concept of the integrated reconnaissance; 3. Enhance the capability for "battlefield visualization"; 4. Provide opportunities for "dynamic targeting". Its secondary focus is equipment-oriented collective training for the Military Intelligence (MI) Company (DS). In this role, it fulfills a subset of the Intelligence Electronic Warfare (IEW) Tactical Proficiency Trainer objective. It provides: 1. Stimulation and crew training on the company's primary mission equipment: Command Ground Station (CGS); Unmanned Air Vehicles (UAV) Tactical Control System (TCS): and All Source Analyst System-Remote Workstation (ASAS-RWS); 2. "system of systems integration of this equipment for company operation; 3. Vertical integration of the company with the Division Analysis Control Element; 4. Horizontal integration with the Brigade s2 and Fire Support Officer.

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# 1. INTRODUCTION

## 1.1 Purpose of CSTAR

The purpose of Combat Synthetic Training Assessment Range (CSTAR) is to create a collective training system designed to enhance integrated combined arms training for brigades in garrison and at the Combat Training Centers (CTC). Its primary purpose is the development and evaluation of battle command capabilities that accrue from organizational and technological changes at the brigade level that: 1. increase battle space (time, scope, and resolution); 2. promote the concept of the integrated reconnaissance; 3. enhance the capability for "battlefield visualization"; 4. provide opportunities for "dynamic targeting". Its secondary focus is equipment-oriented collective training for the Military Intelligence (MI) Company (DS). In this role, it fulfills a subset of the Intelligence Electronic Warfare (IEW) Tactical Proficiency Trainer objective. It provides: 1. stimulation and crew training on the company's primary mission equipment: Command Ground Station (CGS); Unmanned Air Vehicle (UAV) Tactical Control System (TCS); and All Source Analyst System-Remote Workstation (ASAS-RWS); 2. "system of systems integration of this equipment for company operation; 3. vertical integration of the company with the Division Analysis Control Element; 4. horizontal integration with the Brigade S2 and Fire Support Officer.

## 1.2 Purpose and Scope of Document

The purpose of this document is to report the results of the CSTAR Feasibility Analysis Study (FAS). The purpose of the FAS was to select the exercise driver which will best meet the needs for CSTAR, and to identify how the exercise driver might be integrated with the instrumented live exercise and the sensor models. This document discusses the constructive combat model recommended to serve as the exercise driver for CSTAR and identifies the issues related to integrating the exercise driver with the other systems.

## 1.3 Organization of the Document

The initial portion of this FAS report is organized to discuss our study approach, assumptions, a comparison of each of the models, and technical findings/recommendations, including a discussion on the recommended solution and alternate solutions. This is followed by an analysis of the recommended solution and the alternatives with considerations of technical risk, cost and schedule impacts. Configuration drawings, sub-component descriptions, capabilities and advantages and disadvantages of the recommended solution are provided. Appendix A provides general data and facts in matrix form for the constructive simulation models evaluated. Appendix B provides the CSTAR configuration for both the National Training Center (NTC) Ft. Irwin, CA. and homestation, Ft. Hood, TX. exercises.

# 2. STUDY APPROACH

In accordance with the Government Statement Of Work (SOW) for CSTAR, initial analysis efforts were to determine the optimum exercise driver based on the materiel requirements summary for the CSTAR Warfighter Rapid Acquisition Program (WRAP) Project. In the interest of time, constructive simulation candidates that did not meet several of the basic CSTAR requirements were not fully evaluated

The FAS was conducted over a ninety day period of time. The FAS involved fact finding, analysis of technical data, and on-site visits to the training sites at Ft Irwin, CA. (NTC) and Ft Hood, TX. During the analysis process three in progress reviews (IPR) were conducted with the customer.

## *2.1 Assumptions*

The FAS findings and success of CSTAR are dependent upon several assumptions. These assumptions are discussed in more detail in follow-on paragraphs of the report:

- The exercise driver should be an entity based model.
- The exercise driver should be compliant with the Distributed Interactive Simulation (DIS) standard or the High Level Architecture (HLA) standard.
- The core scenario (live units at NTC and the training scenario at Ft. Hood) and the wrap-around scenario do not need to interact with each other, within the constructive simulation.
- The program has a short life. Functional test will occur in late 1998.

# 3.0 THE BASIC CSTAR SYSTEM

## 3.1 Description

CSTAR is a suite of hardware and software that integrates a training force with elements from a constructive simulation and a number of sensor models. A constructive simulation wraps around the training force providing flank and rear area enemy units to create a larger virtual scenario. Units from the virtual scenario are used to stimulate UAV, Joint Surveillance Target Attack Radar System (JSTARS), Q36/37, and SIGINT sensor models. The sensor model outputs exercise Military Intelligence (MI) units on their primary mission equipment. There are two basic CSTAR configurations. At Ft Irwin, the training force will be instrumented live units. At Ft. Hood, the training force is the units from a constructive entity level simulation. The goal is to increase battle space, promote the concept of the integrated reconnaissance, enhance the capability for "battlefield visualization" and provide opportunities for "dynamic targeting".

CSTAR is a continuation of the CSTTAR (Combat Synthetic Test and Training Range).

## 3.2 Requirements for the Exercise Driver

CSTAR Constructive Simulation requirements include:
Constructive scenario development capability resident at NTC enabling the depiction of a 300 x 300 km, wrap-around scenario portraying flank and second-echelon forces outside the instrumented maneuver box or superimposed over the "live" maneuver box (for artillery and air defense artillery, (ADA) capabilities, not routinely exercised during a rotation). The scenario tool must depict forces at the entity level of resolution (vice aggregate simulation) and have the flexibility to enable NTC controllers to easily adjust the scenario to accommodate late adjustments in the live OPFOR scheme of maneuver. All constructive simulations options should be explored for options consistent with HLA standards and migration strategies to achieve the following minimum capability standards:

(1) 8000 entity capacity within a 300 x 300 km scenario box

(2) units/platforms capable of moving a different speeds with varied distance between units or platforms (e.g. rapid assumption of tactical formations consistent with type of unit, organic equipment, and scenario controller commands)

(3) organization of entities into units within a multi-level hierarchy

(4) platform identification and/or destruction by name

(5) at least 225 separate system types with weapon systems firing signatures

(6) rotary and fixed-wing aircraft

(7) individual soldiers (e.g. SA18 gunner)

(8) ability to set unit view fans

(9) scenarios capable of running unattended for 24 hours

(10) exercise controller ability to resurrect, create, and enplace units on demand

(11) end save and checkpoint save features

### 3.3 Requirements for CSTAR

CSTAR requirements include:
Capability to capture all (e.g. tracks, tanks, bulldozers) live force play through the NTC instrumentation system and convert this data to simulation protocols where it can be integrated with constructive simulation to create a single virtual scenario. This capability must be "upwardly compatible" with programmed changes in the NTC instrumentation system. It is highly desirable that this data be normalized for WGS-84 and support locational accuracy less than or equal to 70 meters.

### 3.4 CSTTAR

CSTTAR was an experiment conducted at the National Training Center (NTC) to create a suite of hardware and software to integrate an instrumented live force with elements from a constructive simulation and a number of sensor models. The constructive simulation was used to generate flank and rear area enemy units within the virtual scenario that could stimulate sensor models to exercise MI units on their primary mission equipment. The goal was to prove that such a link was possible.

CSTTAR system consisted of live instrumented units, a constructive entity level simulation, a DIS converter, a Protocol Data Unit (PDU) data logger, a High Resolution System Stimulator (HRSS), and a number of sensor models.

The live units were part of a training exercise. Their movements and activities were tracked by the Central Instrumentation System (CIS). The NTC-CIS input the position of the live units to a DIS Converter which put Entity State PDUs for the live elements on the DIS network.

CSTTAR used Janus 6000 for the constructive wrap-around exercise driver. Janus 6000 is a DIS version of Janus tailored to the specific needs of the experiment. Capabilities of Janus 6000 include:

1. Plays 8000 entities
2. Can aggregate entities and units into higher level units
3. Aggregated units can be given routes and deployed as a unit

4. Puts out DIS entity state PDUs
5. Adjustable PDU rate
6. Unit hide feature
7. Random unit attrition

The hide feature allows Janus to turn off sending PDUs for certain units. In the experiment scenarios, some units were both live and constructive. The DIS converter filtered out PDUs of live units outside of the live play box. Janus was responsible for controlling and sending out PDUs for units while they moved through the wrap-around area. When units crossed the boundary between the wrap-around area and the inner live play box, the responsibility for generating PDU for these units changed. The hide feature was essential for the CSTTAR experiment but has not been kept for Janus 6.88D.

The ability to give movement routes to higher level units greatly reduces the amount of operator interaction required. The implementation of this capability in Janus 6000 tried to maintain the unit's formation by ignoring terrain effects on the movement. Janus considered two movement environments: on road and cross country. Another side effect occurs when the unit changes direction. To maintain the unit formation, the unit formation is simply rotated around the lead element. Elements of the unit far from the lead entity will jump, sometimes great distances. Although this implementation is acceptable for the wrap-around scenario, it would not be for primary training exercise conducted Ft. Hood.

For CSTTAR Janus was run from White Sand Missile Range (WSMR) on a single HP C180 workstation and was connected to the NTC with a T1 line. The addition of DIS capability did not adversely affect Janus performance. The T1 line was not a dedicated line. Generally, the T1 line was sufficient to handle the network traffic between WSMR and NTC. Network problems that did arise were due to the high volume of network traffic from other sources. The potential bottleneck is the HRSS' ability to process the PDUs it receives. The load on the HRSS can be reduced or leveled out by fine tuning Janus parameters which set the frequency units are updated, the fraction of units updated per cycle, and the interval between PDUs.

Janus 6000 did not interact with the live exercise. Significant performance gains could be realized because the wrap-around Janus exercise had no knowledge of the live entities. The Line Of Sight (LOS) calculations performed in target detection is the most intensive user of CPU time in Janus. Janus does not detect units belonging to the same workstation, so the most CPU intensive algorithm was not exercised. Although LOS calculations were not performed, the process of filtering out large numbers of same workstation units in the target acquisition process had a significant affect on performance. To improve performance, the Janus data base was manipulated to reduce the distance to which units searched for targets. In other versions of Janus, such as the training versions

(Janus 6.3 and 7.0), a scenario of 1000 to 1200 units on terrain with a light to moderate number of terrain features engaged in an intense fire fight, Janus can just run in real time. At Ft Hood the simplest and easiest implementation would be to run a single scenario that includes the main training exercise of BLUFOR and OPFOR units and the wrap-around OPFOR units. It would be unrealistic to expect Janus to run such a scenario on present training hardware in real time. The only feasible Ft Hood exercise configuration is to run two or more Janus scenarios; one for the main training exercise and the other scenarios for the wrap-around portion. The main training scenario and the wrap-around scenarios would need to use different databases.

The HRSS receives PDUs from Janus and the instrumented live units from the DIS network. The HRSS performs three functions. It maintains the single entity-level Ground Truth of the virtual scenario. The HRSS can also de-aggregate high level organizations down to the entity level using posture-specific deployment templates. The de-aggregation function was not required for Janus 6000, but could be used if Janus aggregated units or if an aggregate level constructive simulation such as Brigade/Battalion Battle Simulation (BBS) or Corps Battle Simulation (CBS) were used. The third function of the HRSS is to act as an interface between the virtual scenario and the sensor models. Only information on units within the sensor's area of interest are passed to the sensor model.

## 4.0 MODEL COMPARISON

Eight models and systems were examined: Joint Conflict and Tactical Simulation (JCATS), Joint Conflict Model (JCM), Joint Tactical Simulation (JTS), Janus, BBS, Synthetic Theater Of War (STOW), ModSAF, and CBS. Five of the systems, JCATS, JCM, JTS, Janus, and ModSAF, are entity based models. Two of the systems, BBS and CBS are aggregate level models. The other system, STOW, is not a model itself. The functionality of each system was compared against the requirements for the CSTAR exercise driver. Other considerations included cost, availability, and hardware.

None of the systems met all of the requirements. All of the entity based models met the following requirements:

(2) units/platforms capable of moving a different speeds with varied distance between units or platforms (e.g. rapid assumption of tactical formations consistent with type of unit, organic equipment, and scenario controller commands)

(5) at least 225 separate system types with weapon systems firing signatures

(6) rotary and fixed-wing aircraft

(7) individual soldiers (e.g. SA18 gunner)

(8) ability to set unit view fans

(9) scenarios capable of running unattended for 24 hours

(11) end save and checkpoint save features

Strictly interpreted, Janus does not meet 300 x 300 km play box requirement and JTS does not meet the 8000 entity capacity requirement. This is not a serious drawback for the models because multiple scenarios can be run simultaneously to achieve the desired results.

At this point, HLA compliance does not appear to be critical. Only ModSAF currently has a HLA bridge. The HRSS is an essential piece of the CSTAR configuration and it is not HLA compliant at this time. A HLA bridge would have to be developed to replace the DIS converter to bridge between the instrumented live exercise and the HLA network. The alternative is to use DIS until the selected constructive model, HRSS, and HLA converter become available. Only ModSAF is DIS compliant in the narrow sense. The other entity level models have bridges or a limited DIS capability built into them which make the models DIS compatible. For the purposes of CSTAR, this limited capability is sufficient. The most important function is the ability to produce entity state PDUs. The wrap-around scenario can be independent of the exercise scenario as demonstrated by CSTTAR.

The number of operators, and thus workstations, required to run an 8000 entity scenario is an important factor in determining the best constructive simulation. Realistically, an experienced operator can interact with 200 to 300 icons. With more icons the operator becomes overwhelmed. With large numbers of icons, the display screen becomes cluttered and it is difficult to locate particular units. It is also difficult to react to events in a timely manner. This limiting factor applies to all of the simulations. There are some things that can mitigate these problems and even increase the number of icons that an operator can manage.

First, a carefully planned and coordinated scenario can significantly reduce the amount of interaction required. In effect, the burden of interacting with the scenario is shifted from execution to the set up or planning phase. An advantage of shifting interaction to the set up phase is that a number of canned scenarios can be developed as an one time effort. The scenarios are then reused for different exercises. For Ft Irwin, where there is a limited number attack corridors, this approach can save a lot of man power.

Second, the ability to organize entities into hierarchical aggregates and manipulate those aggregates allows an operator to control more entities. There are two possible, distinct levels of aggregation. At the graphical display level, a hierarchy of unit icons are displayed at the workstation. Subordinate units can be displayed by de-aggregating higher level aggregates and higher level units can be displayed by aggregating subordinate units. Aggregation at the graphical display level can reduce screen clutter and ease the operators job. It improves performance by reducing the amount of graphics that have to be updated. At the control level, the actions assigned to a unit are propagated down the hierarchy to the entity level. Hierarchical control reduces the number of key strokes and mouse picks necessary to control a large force. Both types of aggregation can be used to increase the number of entities that can be manipulated by the operator and thus reduce the number of operators and workstations required to run a scenario. Most models implement both types of aggregation. The details of the implementation of the hierarchical aggregation at the control level was critical to the evaluation process.

The constructive simulation must provide some mechanism to deal with the boundary between the live exercise and the wrap-around scenario. In a fully DIS compliant environment, control or ownership of an entity can be passed between federates, in this case the live instrumented exercise through the DIS converter and the constructive simulation. In CSTTAR, this was accomplished by having the DIS converter stop sending out entity state PDUs for live units leaving the live play box and having Janus stop sending out PDUs for constructive units leaving the wrap-around box. An alternative approach for the constructive simulation is the ability to add units to the simulation when a live unit leaves the play box and to delete units from the simulation when it leaves the wrap-around area.

The constructive simulation does not need to be able to capture the live exercise play, because the HRSS maintains the virtual simulation. If the constructive simulation is unaware of the live entities, there is no chance of interaction between the two realms. Otherwise, interaction can be limited by putting the constructive units in a hold fire status. Constructive units will still try to acquire the live units which might put too much of a performance burden on the simulation. The time and resources spent trying to acquire targets can be reduced by shortening the detection or visibility range of the constructive units in the wrap-around scenario.

## 4.1 JCATS

### 4.1.1 Model Description

The Joint Conflict and Tactical Simulation (JCATS) is a multi-sided interactive entity level conflict simulation to be used as an exercise driver and a tool for training, analysis, and mission planning. JCATS uses a client-server architecture. The server manages the battle. Clients handle all the graphics displayed at the local workstation as well as requested LOS fan calculation and display. Later releases should adhere to the HLA standard. JCATS can model about 20,000 entities on a play box of 600x600 kilometers. JCATS models dismounted infantry, tracked and wheeled vehicles, fixed and rotary wing aircraft, ships, and submarines. JCATS provides very detailed modeling of small group tactics in rural or urban terrain modeling day or night operations with artificial lighting. It allows for dynamic hierarchical aggregation and de-aggregation of units during the game allowing the user to play large numbers of entities with fewer operators. JCATS should be able to run a two week exercise without interruption. It has the ability to introduce new entities dynamically into the game. Other features include a direct fire fratricide model, tracking of missed shots, direct fire suppression, fatigue, resupply of fuel and ammunition, breaching of barriers, weather and terrain affects on movement and acquisition, and a high resolution minefield model.

### 4.1.2 Advantages

The initial JCATS release will meet or exceed all of the requirements for the simulation driver for CSTAR except the requirement that the model be HLA or DIS compliant. It is the newest entity level constructive simulation and incorporates features from other combat simulations, especially JCM and JTS, as well as new features not found elsewhere.

- JCATS has a client-server architecture that allows some CPU intensive functions to be performed by the client. JCATS should be able to play about 20000 entities in real time.
- JCATS can play a 600x600 km play box.
- There are plans to make JCATS HLA compliant in the future.
- JCATS has separate fixed and rotary wing aircraft models. The fixed wing model gives JCATS a better representation of fixed wing play than does Janus.
- JCATS should be able to run a two week exercise without interruption.
- Has the capability to introduce new entities dynamically during the game. Entity characteristics can be modified during the game. It has the ability to remove entities during the game. JCATS is planning to have a resurrection function, but it may not be in version 1.0
- It runs on the same hardware, HP 9000 Series 700 workstations, as the current tactical combat trainer simulation. A HP C or J class workstation is recommended for the server.
- Aggregated units can be given movement routes. Units will attempt to stay in formation during maneuvers. There is a set of standard formations that can be used or the user can define the formation of the unit. The aggregated unit moves at the speed of the slowest moving element. If an element stops for obstacles or terrain features, or becomes mobility killed, that element is dropped from the unit, and the aggregated unit continues. This level of aggregate control should allow operators to manage 200 or more entities.

### 4.1.3 Disadvantages

- JCATS 1.0 is not scheduled to be released until late April 1998. Initial software releases are not usually as stable and reliable as mature products. The initial release may not be DIS compliant and will not be HLA compliant. JCATS has not been tested in a distributed environment with other simulations or live elements.

#### 4.1.4 Issues

- JCATS version 1.0 may not support dynamic aggregation and de-aggregation of units during play. If not, JCATS may not have the flexibility needed to easily manage large numbers of entities.
- The initial JCATS release will not be HLA compliant. Initially, it was planned to modify and use the DIS bridge of JTS. Recent events have put this plan in jeopardy. The JCATS Configuration Control Board (CCB) meets in December 1997 and will decide what distributive functionality will be used and when it will be available. JCATS is not a viable option for CSTAR without HLA or DIS functionality. If JCATS is made DIS compliant, it can be used without modification to the HRSS or the DIS converter for the instrumentation system. If JCATS is made HLA compliant instead, the HRSS and DIS converter will have to be modified.
- JCATS may not be released in time for the initial CSTAR test. A Beta test version may be available before the April 1998 release date. Once a stable HLA/DIS version of JCATS becomes available, it will be worth while to try it in the CSTAR configuration.
- The treatment of aggregated units cuts corners that places JCATS between an entity and aggregate level simulation. Like Janus 6000, the aggregate movement algorithm largely ignores terrain effects on individual entities. JCATS moves aggregated units from the unit's center of mass, then disperses the entities according to a formation template. Entities within aggregates do not acquire targets. The aggregate's sensors are pooled. Acquisition is performed for each type of sensor from the aggregate's center of mass. Direct fire engagements are performed on the entity level and the shooter must have LOS to the target.
- JCATS would require some upgrades to the current hardware suite used by Janus. The original Janus hardware suite used HP series 9000, 715-50 workstations. The workstations have 64 Mbytes of Random Access Memory (RAM) and a 1 Gbyte internal disk drive. The simulation host workstation has an additional 2 Gbyte external disk drive. Several sites have already upgraded their host workstations. JCATS client workstations can run on the current 715-50 workstations, although 128 Mbytes of RAM and 2 Gbyte disk drives are recommended. The server workstation can run on the 715 class, but the more powerful C or J class machines are recommended. The server workstation requires a minimum of 128 Mbytes and 256 is recommended. It also requires a minimum of 4 Gbytes hard disk capacity, and recommends 6 Gbytes. The minimum needed to upgrade the current hardware suite is

the purchase of a C or J class workstation and 4 Gbytes of external disk drive capacity.

## 4.2 JCM

### 4.2.1 Model Description

The Joint Conflict Model (JCM) is a multi-sided interactive entity level conflict simulation used as an exercise driver and a tool for training, analysis, and mission planning. JCM is DIS compliant. JCM can model about 20,000 entities on a play box of 600x600 kilometers. JCM models dismounted infantry, tracked and wheeled vehicles, fixed and rotary wing aircraft, and brown water naval operations. JCM can run a continuous two week exercise. It has the ability to introduce new entities dynamically into the game. Other features include resupply, breaching of barriers, weather and terrain affects on movement and acquisition, command and control graphical operations planning, and a high resolution minefield model.

### 4.2.2 Advantages

- JCM is available now.
- JCM can play about 20000 entities in real time.
- JCM can play a 600x600 km play box.
- JCM is DIS compatible.
- JCM has separate fixed and rotary wing aircraft models. The fixed wing model gives JCM a better representation of fixed wing play than does Janus.
- JCM is able to run a two week exercise without interruption.
- JCM has the capability to introduce new entities dynamically during the game. Entity characteristics can be modified during the game.

### 4.2.3. Disadvantages

- JCM runs on VAX/VMS computers and DEC Alpha workstations running Open VMS. The existing hardware (HP 9000 series 700 workstations) cannot be used.
- JCM is slated to be phased out when JCATS is released. It will not be supported after mid 1998.
- JCM does not support the organization of entities into multi-level hierarchies.
- Units cannot be aggregated. More operator interaction is required to control a force which reduces the number of icons that can be controlled on a workstation.

- There are no plans to make JCM HLA compliant.

### 4.2.4 Issues

- JCM has a short future because it is being replaced by JCATS. JCM does meet a number of critical requirements for CSTAR: entity count, play box size, and DIS compliance. If JCM and JCATS ran on the same hardware platforms, JCM would be a viable interim solution to JCATS.

## *4.3 JTS*

### 4.3.1 Model Description

The Joint Tactical Simulation (JTS) is a multi-sided interactive entity level conflict simulation used as a tool for training, analysis, and mission planning. JTS provides detailed modeling of small group tactics in rural or urban terrain for day or night operations with artificial lighting. JTS can model 2,000 entities on a play box of 600x600 kilometers. JTS models dismounted infantry, tracked and wheeled vehicles, fixed and rotary wing aircraft, and brown water naval operations. It has the ability to introduce new entities dynamically into the game. Other features include a direct fire fratricide model, tracking of missed shots, direct fire suppression, fatigue, resupply of fuel and ammunition, breaching of barriers, weather and terrain affects on movement and acquisition and command and control graphical operations planning.

### 4.3.2 Advantages

- JTS has a DIS gateway.
- JTS can play a 600x600 km play box.
- Has the capability to introduce new entities dynamically during the game.
- It runs on the same hardware, HP 9000 Series 700 workstations, as the current tactical combat trainer simulation.

### 4.3.3 Disadvantages

- JTS is intended for small group tactics on very detailed terrain. It can play about 2000 entities, which is not enough for CSTAR.
- JTS will not be supported after JCATS is released in mid 1998.
- JTS does not support the organization of entities into multi-level hierarchies.

- Because units cannot be aggregated, more operator interaction is required to control a force which reduces the number of icons that can be controlled on a workstation.
- JTS also requires several Commercial Off The Shelf (COTS) software packages.
- There are no plans to make JTS HLA compliant.

### 4.3.4 Issues

- JTS can only play 2000 entities. Because JTS is DIS compliant, a number of JTS simulations can be run simultaneously on the DIS network to achieve the required number of entities.
- JTS has a short future because it is being replaced by JCATS. JTS meets the requirements for play box size and DIS compliance and can reach the entity count requirement by running multiple scenarios. Also in its favor is that it runs on the same hardware as the current training model. Its major drawbacks are that it requires COTS software and it does not support a multi-level hierarchy of units.

## *4.4 Janus*

### 4.4.1 Model Description

Janus, named for the Roman god of portals, is a multi-sided interactive entity level conflict simulation used as an exercise driver and a tool for training, analysis, and mission planning. There are plans to make Janus HLA compliant in the future. Janus models dismounted infantry, tracked and wheeled vehicles, and rotary winged aircraft. Janus supports dynamic hierarchical aggregation and de-aggregation of units during play. Janus is able to run uninterrupted for up to two weeks. Janus models direct fire fratricide, direct fire suppression, resupply of fuel and ammunition, breaching of barriers, weather and terrain affects on movement and acquisition. It has a high resolution minefield model.

Janus comes in several variants. The version being considered as the CSTAR exercise driver is known as Janus 6.88D. Janus 6.88D is DIS compatible. Janus supports dynamic hierarchical aggregation and de-aggregation of units during the game allowing the user to play larger numbers of entities with fewer operators.

### 4.4.2 Advantages

- Janus is the army tactical combat trainer. It is fielded at over forty sites, including the National Training Center (NTC) and Fort Hood. While there are similarities between the training version, there are significant differences. The staffs at NTC and Ft Hood are familiar with Janus and would need little retraining.

- Janus 6000 was used for the original CSTTAR tests. Janus met the goals of those tests. Janus 6.88D is the follow up to Janus 6000.
- Janus has a simple and intuitive interface for the operator. Soldiers can be taught to interact with the simulation in four to twelve hours. This can be a significant factor if professional operators are not used.

### 4.4.3 Disadvantages

- Janus can play a 300x300 km box if terrain of sufficiently low resolution terrain data was available. The limiting factor for play box size in Janus is the static allocation of the terrain arrays. Janus has a fixed 1000x1000 element array of terrain cells. If the terrain resolution is 200 meters, the maximum play box is 200x200 kms. Common terrain resolutions are 50, 100, and 200 meters. Increasing the array allocation to 1500x1500 elements to accommodate a 300x300 km play box more than doubles the memory used to store terrain cell data. This increase alone should have little affect on performance. Janus uses about a third of the Hewlett-Packard 715-50's 64 Mbytes of RAM. There is room for growth before swapping occurs. The performance affects would be most noticeable during scenario initialization, checkpoint saves, and graphical updates when zooming. An alternative is to modify the terrain filter utility to create lower resolution terrain from higher resolution master terrain files.
- Janus 6.88D does not allow units to be inserted into play or removed from play during execution. It also does not provide for the resurrection of dead units.
- The capability to give an aggregated unit a movement route is unsatisfactory. When a route is given to an aggregated unit, the route is copied 'In-line' to the other elements in the unit. All the elements in the unit converge on the first movement node of the route, then follow the route to the end in an irregular column. Unit formation and spacing is not maintained unless the unit is traveling in a column on a road. To make units move in other formations, the operator must either give a movement route to each element of the unit or copy the route to other elements and then adjust each route. This is a time consuming operation that limits the number of icons that a user can control.
- Janus does not distinguish between rotary and fixed wing fliers. Janus only has a rotary wing model, but replicates fixed wing aircraft as fast helicopters.
- Janus cannot add units to a scenario or delete units from a scenario during execution. Without the ability to add and delete units and without the ability to 'hide' units, that is stop sending entity state PDUs for a unit, Janus cannot be used as the exercise driver.

- Janus 6000 was specifically tailored to meet the needs of CSTTAR. The ability to hide units, the ability of units to move in formation, and the 'Death Angle', a random attrition feature, have not been included in Janus 6.88D. It will take TRAC-WSMR 8 to 9 months to put this functionality into Janus 6.88D. There is a one time cost of $250,000 and an annual maintenance fee of $110,000.

- Janus 7.0 is the current Army tactical trainer model. Janus 7.0 has multiple kill categories, hulks, building rubbling, insertion of units into the scenario, repair, medical aid, and obstacle detection. Janus 6.88D lacks all these capabilities. It is unlikely that the training community will be willing to move to a version of Janus that lacks features deemed necessary.

### 4.4.4 Issues

- Janus 6.88D would require some upgrades to the current hardware suite used by the training sites. The fielded training version of Janus has a hardware suite consisting of HP series 9000, 715-50 workstations. The CSTTAR experiment used a HP C-180 workstation. The C-180 is about 3.5 times faster than the 715-50 workstation. Even with the faster workstation, the data base had to be manipulated to run the exercise in real time. A workstation faster than the C-180 is probably required for the host workstation. The current 715-50 workstations can be used for display workstations.

- Janus 6000 had the capability to maintain an aggregated unit's formation while it maneuvered. Terrain effects on movement were ignored. Only the column formation is supported in Janus 6.88D. The only way to get units to move in formations other than columns is give individual movement routes to each entity. The unit would have to be monitored closely during maneuvers so adjustments can be made to maintain the formation. This implementation does not have much utility for either the wrap-around scenario or, in the case of Ft Hood, the inner training scenario. The Janus 6000 capability can be put back into Janus 6.88, but ignoring the effects of terrain on movement is unacceptable in the training exercise at Ft Hood. The ultimate solution is to modify Janus so that 1) units move in formation; 2) terrain affects the movement of individual entities and the unit as a whole; 3) units make rounded corners instead of pivoting around the lead unit or center of mass; and 4) units circumvent obstacles and impassable terrain features when possible.

- Janus can only play a 200x200 km play box because lower resolution terrain is unavailable. To achieve the full 300x300 km play box, multiple Janus scenarios would have to be run simultaneously for the wrap-around portion. Currently Janus 6.88D cannot be used as the simulation driver using multiple scenarios is it does not have the ability to add or delete units during play or the ability to 'hide' units. If the ability to 'hide' units were put into Janus 6.88D, the boundary between wrap-around scenarios would be treated in the same way as the boundary between the wrap-around scenario and the exercise scenario. There is an area of overlap between scenarios where units are hidden. Units passing through two or more scenarios are added to each scenario they will pass through during scenario creation. When a unit of one scenario enters a 'hide' zone between adjoining wrap-around scenarios, a unit in the adjacent scenario will leave its 'hide' zone. While the scheme is workable, it adds a great deal of complexity to the management and planning of the wrap-around scenario and requires a great deal of coordination between operators.

- Increasing the Janus play box from 200x200 km to 300x300 km by either increasing the terrain cell array or by reducing terrain cell resolution will have an adverse affect on performance. This is because the additional 50,000 square kilometers would have terrain features. LOS and movement algorithms both search terrain features. The addition of a terrain feature geometrically increases the time required to perform LOS calculations. The affect on performance would be less on the relatively barren Ft Irwin and Ft Hood terrains than at other CTC sites.
- Janus will be made HLA compatible in the future. At this time it is not known which of the Janus versions will become the HLA version or what functionality will be included in it.

## *4.5 BBS*

### 4.5.1 Model Description

The Brigade/Battalion Battle Simulation (BBS) is used for command post exercise (CPX) training support. Its intended training audience is the BDE/BN commanders and staff. BBS is a two-sided, free play simulation set in a real-time environment. The simulation supports maneuver, fire support, air defense, engineering, Nuclear, Biological, Chemical (NBC) warfare, tactical air, air transport, Army aviation, logistics, maintenance, medical, personnel administration, higher headquarters functions, and threat operations. Its strengths are combat support and combat service support, not tactics and maneuver. BBS is not an entity level simulation. It is neither DIS nor HLA compliant.

### 4.5.2 Advantages

- BBS is an aggregate level simulation. Operators should be able to control more entities.
- BBS supports aggregation and de-aggregation of units during play.

### 4.5.3 Disadvantages

- BBS is not an entity level simulation. Entities within an unit do not have locations and direction of movement.
- There are no plans to make BBS HLA compliant.

- BBS is not DIS or HLA compliant.
- The typical BBS play box is 50x50 km.
- BBS does not use the same hardware as the current tactical combat trainer.

### 4.5.4 Issues

- BBS is not an entity level simulation, does not support DIS or HLA, and does not support a 300x300 km play box. It cannot be recommended for CSTAR.

## 4.6 STOW

### 4.6.1 Model Description

STOW is a suite of software and hardware used to link virtual and constructive simulations. On one side is the constructive simulation BBS (or EAGLE). BBS is an aggregate level model, not an entity based model. On the other side is a DIS network consisting of ModSAF and manned virtual simulators. ModSAF is a semi-automated force model that models vehicles in detail to populate the virtual world of the manned simulators. Between BBS and ModSAF is an Operational State Interpreter (OPSIN). The OPSIN passes information on aggregated BBS units to ModSAF when such units enter into the Sphere Of Influence (SOI) of a manned simulator. ModSAF de-aggregates the unit into separate entities and positions them based on their formation. BBS retains control of the unit. ModSAF sends out entity state DIS PDUs for the separate entities of the BBS unit. The OPSIN also communicates back to BBS the results of engagements between elements of BBS aggregates and the manned simulators. BBS units are de-aggregated only when they enter a sphere of interest of one of the manned simulators. The unit is dropped from ModSAF when it leaves the SOI of the manned simulator. The manned simulators are not needed for CSTAR.

### 4.6.2 Advantages

None.

### 4.6.3 Disadvantages

- STOW uses a aggregate level simulation. Aggregated units are only decomposed into individual entities when the units come in range of a manned simulator. At all other times, individual entities do not a specific location or direction of movement.
- The main drawback is that STOW requires both a BBS and ModSAF suite of hardware. ModSAF is required to provide entity level information. BBS does not provide anything to CSTAR.

- Both BBS and ModSAF typically use a 50x50 km play box.

### 4.6.4 Issues

- A scheme of using an aggregate level simulation to model a large force which passes off selected units to ModSAF to de-aggregate and model in greater detail would provide sufficient detail to simulate various sensor models. Using enough ModSAF workstations to decompose all of the BBS aggregated units into entities is not feasible. The alternative is to develop a mechanism to communicate to the OPSIN the SOI of the various sensor models so that only those units that are of possible interest to the sensor models are decomposed into entities. The HRSS was the interface between the sensor models and the virtual simulation for the CSTTAR experiment. It may be possible for the HRSS to relay the sensor footprint to the OPSIN. It would require building interfaces between the HRSS and the OPSIN and modifying the HRSS and possibly the OPSIN. This scheme increases the complexity of the system. A more serious defect is that the BBS units do not become part of the virtual scenario expect through ModSAF, and then only for short periods of time. There are no PDUs for the BBS units to log so most of the wrap-around scenario is left out of the After Action Review (AAR).

## *4.7 ModSAF*

### 4.7.1 Model Description

ModSAF is a semi-automated forces model. ModSAF simulates a wide range of air and ground combat vehicles and personnel including tanks, infantry fighting vehicles, individual combatants, mortars and artillery, air defense systems, Armored Personnel Carriers (APC), command posts and maintenance and supply vehicles, aviation elements, close air support, minefields and breaching equipment. The primary role of ModSAF is to provide entities for manned simulators to interact with. ModSAF entities are modeled in a great deal of detail to achieve the necessary realism required. ModSAF can also be used as a tool for training tactics and command and control procedures for unit commanders and their staffs. ModSAF or one of its derivatives is tentatively scheduled to become the army's company level tactical trainer in the future. ModSAF may also be used for analysis and mission planning. ModSAF is fully DIS compliant. A scenario can be distributed over a virtually unlimited number of workstations to reach the desired number of entities.

### 4.7.2 Advantages

- ModSAF is already fully DIS compliant. ModSAF has a HLA gateway which should be sufficient for CSTAR.

- ModSAF runs on a number of platforms, including Sun, SGI, HP, DEC alpha, and Pentiums running Linux. ModSAF comes with a PDU logger.
- ModSAF supports the organization of entities into multi-level hierarchies.
- Units can be added to a scenario on demand.
- ModSAF has the capability to capture the live NTC play to create a virtual scenario.

### 4.7.3 Disadvantages

- To model ModSAF entities in the detail needed for manned simulators consumes a lot of CPU time. This means that only 60 to 120 entities can be modeled per workstation. To achieve an 8000 entity count, a minimum of 65 workstations and operators would be required. This makes ModSAF prohibitively costly as the wrap-around exercise driver for CSTAR. If ModSAF could improve its performance to the point where it can handle 200 plus entities on a workstation, it would become a practical alternative to either Janus or JCATS.
- ModSAF has a number of memory leaks. Memory leaks occur when memory is not released. Eventually the workstation runs out of memory and crashes. The memory leak problem makes the goal of running for 24 hours doubtful. In at least one version of ModSAF enough of the leaks have been plugged that ModSAF can run over 24 hours. As these fixes are integrated into the base line ModSAF should be able to run longer.
- The typical size exercise box for ModSAF is 50x50 km.

### 4.7.4 Issues

- ModSAF has already been ported to Pentiums running Linux. Pentiums are a relatively cheap platform and become more attractive as they become faster. But any potential gains in the number of entities that ModSAF can play will likely be offset by enhancements to improve and broaden the model.
- ModSAF is more complex and difficult to learn than Janus. It would require additional training time for operators or the use of a professional staff.
- ModSAF is fully DIS compliant. It sends out entity state PDUs every five seconds for stationary units, and more often for moving units. Janus and JCATS update units less often and therefore send fewer entity state PDUs. ModSAF also sends out more types of PDUs. The total number of PDUs put out by ModSAF may not overload the network, but may overwhelm the HRSS.

## 4.8 CBS

### 4.8.1 Model Description

The Corps Battle Simulation (CBS) is a Man-in-the-Loop simulation which supports training of a corps commander and his battle staff, major subordinate commands, and major subordinate elements of headquarters of the corps in conduct of deep operations, air-land battle operations. It exercises command and staff skills in the control of joint operations, tactical forces, combined arms forces, maneuver forces, and the combat support and combat service support systems in an operational/tactical environment. The simulation supports maneuver, fire support, air defense, engineering, NBC warfare, tactical air, and logistics. CBS is not an entity level simulation. It is neither DIS nor HLA compliant.

### 4.8.2 Advantages

- CBS is a aggregate level simulation. Operators should be able to control more entities.
- The CBS exercise box exceeds the 300x300 km requirement.
- CBS supports aggregation and de-aggregation of units during play.

### 4.8.3 Disadvantages

- CBS is not an entity level simulation. Entities within an unit do not have locations and direction of movement.
- There are no plans to make CBS HLA compliant.
- CBS is not DIS or HLA compliant.
- CBS does not use the same hardware as the current tactical combat trainer.

### 4.8.4 Issues

- CBS cannot be recommended for CSTAR because it is not an entity level simulation, and does not support DIS or HLA.

# 5.0 RECOMMENDED MODELS

The entity based models received the greatest consideration in this study. The functionality of the models were compared against the CSTAR requirements and the functionality of the other candidate models. Other factors include the level of operator interaction required to manage a large number of entities, compatibility of the model's hardware with the existing hardware, and the training benefits of the competing models examined.

JCM was not recommended because it will not be supported after mid 1998, it runs on a different platform than the current training model, and it will not be made HLA compliant. JTS was rejected because it will not be supported after mid 1998, it requires purchasing COTS software, it does not support aggregation of entities into multi-level hierarchies, and it will not be made HLA compliant. BBS was rejected because it is not an entity level model and is not DIS or HLA compatible. ModSAF was not recommended because the hardware and operators required to manage a large number of entities is prohibitive and the model is not stable at this point. CBS was rejected because it is not an entity level model and is not DIS or HLA compatible. STOW was not recommended because it has the same flaws as BBS and ModSAF, to model all the simulated entities is redundant, and there is no filtering mechanism to model only the portion of the entities of interest to the sensor models.

## 5.1 Janus 6.88D

This study recommends the use of the analytical Janus 6.88D simulation provided that the ability to hide units is put back into the model. Strong consideration should also be given to restoring the movement of aggregates that maintain formation and the ability to adjust the PDU output rate. The determining factor is the schedule. The modifications can be made to Janus in eight to nine months. It is unknown at this time when a DIS or HLA compliant version of JCATS will be available.

## 5.2 JCATS

JCATS appears to be the best model. JCATS will be able to play more entities than Janus and will not have to resort to manipulating the data base to maintain real time. JCATS can accommodate a 300x300 km exercise box where Janus will have to run multiple scenarios to achieve the same coverage. JCATS has a fixed wing aircraft model. Janus models fixed wing aircraft as helicopters. Units can be added and removed from JCATS, but not Janus, during play. JCATS also has the ability to deploy units during play. JCATS provides more useful and robust control over aggregated entities. JCATS supports more formations than Janus. The modeling of movement and acquisition for aggregated units loses some fidelity compared to a pure entity level model such as Janus. JCATS can be fielded at training sites through NSC with no software costs. At this time it is not known whether version 1.0 will be DIS compliant. It will not be HLA compliant.

This would seem to eliminate it as the constructive simulation driver. A number of options were considered.

One option considered was to use Janus, JCM, or JTS until JCATS becomes DIS or HLA compliant. Use of JCM in the interim is possible but costly. JCM does not run on the same hardware as either the current training model or JCATS. It would require buying hardware that will used for only a short period of time. The use of JTS as an interim simulation is not feasible either. JTS can use the same hardware as the current training model and JCATS but requires the purchase of expensive COTS software which would not be used once JTS is replaced. Another factor weighing against JTS is it does not support the organization of entities into multi-level hierarchies. This reduces the number of entities that can be controlled by each operator.

If DIS compliant, serious consideration should be given to incorporate JCATS as the constructive simulation after it is released in April or May 1998. The capabilities advertised for JCATS meet more of the CSTAR requirements than Janus. Additionally the second JCATS release in August or September 1998 may be HLA compliant and thus should enable a smooth transition to the Warfighter Simulation 2000 (WARSIM) and WARSIM Intelligence Module (WIN) when they become available.

# 6.0 IMPLEMENTATION / INTEGRATION APPROACH (REQUIREMENT REMOVED FROM UDO, IPR, 13 NOV 97)

## *6.1 Discussion (REQUIREMENT REMOVED FROM UDO, IPR, 13 NOVN 97)*

This approach includes developing, testing and installing the CSTAR simulation at FT. Irwin, NTC and a "home station training" suite at FT. Hood, TX. We intend to develop procedures and test the constructive simulation with the interface of the Intelligence Models JSTARS, Guardrail and UAV it stimulates in Orlando with follow-on testing at Ft Hood and at FT. Irwin, NTC.

## *6.2 FT. Hood, TX. (REQUIREMENT REMOVED FROM UDO, IPR, 13 NOV 97)*

## *6.3 FT. Irwin, CA. NTC. (REQUIREMENT REMOVED FROM UDO, IPR, 13 NOV 97)*

# 7.0 ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAR | After Action Review |
| APC | Armored Personnel Carriers |
| ASAS-RWS | All Source Analyst System-Remote Workstation |
| BBS | Brigade/Battalion Battle Simulation |
| BLUFOR | blue force |
| CBS | Corps Battle Simulation |
| CCB | Configuration Control Board |
| CGS | Command Ground Station |
| CIS | Central Instrumentation System |
| COTS | Commercial Off The Shelf |
| CPU | Central Processing Unit |
| CPX | command post exercise |
| CSTAR | Combat Synthetic Training Assessment Range |
| CSTTAR | Combat Synthetic Test and Training Range |
| CTC | Combat Training Centers |
| DEC | Digital Equipment Corporation |
| DIS | Distributed Interactive Simulation |
| FAS | Feasibility Analysis Study |
| Gbyte | giga byte |
| HLA | High Level Architecture |
| HP | Hewlett-Packard |
| HRSS | High Resolution System Stimulator |
| IEW | Intelligence Electronic Warfare |
| IPR | in progress reviews |
| JCATS | Joint Conflict and Tactical Simulation |
| JCM | Joint Conflict Model |
| JTS | Joint Tactical Simulation |
| JSTARS | Joint Surveillance Target Attack Radar System |
| LOS | Line Of Sight |
| Mbytes | mega byte |
| MI | Military Intelligence |
| ModSAF | Modular Semi Automated Forces |
| NBC | Nuclear, Biological, Chemical |
| NTC | National Training Center |
| OPFOR | opposing force |
| OPSIN | Operational State Interpreter |
| PDU | Protocol Data Unit |
| RAM | Random Access Memory |
| SGI | Silicon Graphics, Inc. |
| SIGINT | Signals Intelligence |
| SOI | Sphere Of Influence |
| SOW | Statement Of Work |
| STOW | Synthetic Theater Of War |

| | |
|---|---|
| STTAR | Combat Synthetic Test and Training Range |
| TCS | Tactical Control System |
| UAV | Unmanned Air Vehicle |
| UDO | Unilateral Delivery Order |
| VAX/VMS | Virtual Address Extension/Virtual Memory System |
| VMS | Virtual Memory System |
| WARSIM | Warfighter Simulation 2000 |
| WGS | World Geodetic System |
| WIN | WARSIM Intelligence Module |
| WRAP | Warfighter Rapid Acquisition Program |
| WSMR | White Sand Missile Range |

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# Appendix A Constructive Simulation Model Matrix

# CSTAR
## CONSTRUCTIVE SIMULATION MATRIX

| | Entity Count | Exercise box Dimensions | HLA compliance | Migrating to NTC range changes |
|---|---|---|---|---|
| JCATS | 20k-40k More realistic goal of 20k entities. Scenario/terrain dependent | 600x600 kms. Can play a 6° globe area. Has played a 1000x1000 km box, but there is some distortion at this size. Uses the UTM coordinate system, but can display lat-lon. | JCATS has a requirement to be HLA compliant, but the initial release will not be. It may be compliant by the end of the summer (no promises). A DIS bridge was planned for the first release, but this is now in doubt. | N/A |
| JCM | 20k | 600x600 kms. Can play a 6° globe area. | No. It is DIS compliant through a DIS bridge. | N/A |
| JTS | 2k | 600x600 kms. Can play a 6° globe area. | No. Some DIS capability with a gateway. | N/A |
| Janus | 9999 entities. | 200x200 kms. Play box size depends on the terrain resolution. Maximum of 1000x1000 terrain cells can be played. Most terrain is 50 to 100 m resolution. | No. May become HLA compliant in the future. Has a limited DIS capability. | N/A |
| BBS | 1000 units. Units are typically aggregated. (Not an entity based model) | Variable. Typical exercise box is 50x50km. | no | N/A |
| STOW | STOW is not a simulation. STOW consist of BBS (the constructive simulation), ModSAF (Semi-Automated Forces system), an Operational State Interpreter (OPSIN, it is an interface between BBS and ModSAF which deaggregates BBS aggregated units into separate ModSAF entities), and manned simulators. ModSAF models deaggregated BBS entities at a higher resolution to populate the virtual battle space of the manned simulators. STOW was able to model 500+ entities for the manned simulators. STOWEX replaced STOW-E which used the Simulation Network (SIMNET) instead of ModSAF and the Advanced Interface Unit (AUI) where STOWEX used OPSIN. STOW-E also used the Simulation Control (SIMCON) program as an interface between BBS and the AUI. | N/A | no | N/A |
| ModSAF | Scaleable to virtually any size by adding more workstation. The number of entities that can be played on a workstation varies, depends on the speed of the workstation. The range is between 60 and 120 entities. | Typical exercise box is 50x50km. | There is a HLA gateway. DIS compliant. | N/A |
| CBS | CBS is not an entity based model. | Exceeds 300x300 km. | no | N/A |

# CSTAR
## CONSTRUCTIVE SIMULATION MATRIX

| | Number of Operators Required | Organiztion of entities in multi-level hierarchy | Model availability | Platform ID and destruction by name | Rotary and Fixed-Wing AC |
|---|---|---|---|---|---|
| JCATS | Dependent on skill level of operators and the scenario. Minimally trained operators can manage about 70 icons, skilled operators can manage 200 plus icons effectively. | yes | Spring-Summer 1998. A beta release may be available in March. A HLA compliant version may be available later in 98. | yes | yes |
| JCM | Dependent on skill level of operators and the scenario. Minimally trained operators can manage about 70 icons, skilled operators can manage 200 plus icons effectively. | no | Now | yes | yes |
| JTS | Dependent on skill level of operators and the scenario. Minimally trained operators can manage about 70 icons, skilled operators can manage about 200 icons effectively. | no | Now | yes | yes |
| Janus | Dependent on skill level of operators and the scenario. Minimally trained operators (up to 1.5 days training) can manage about 70 icons. Professional operators can manage 200 plus icons effectively. Defensive workstations can handle more icons than the attacking force's workstation. | yes | Janus 6.88D is available now. Any tailoring will take 8-9 months | Units can be named, but are still identified by unit number. | Fixed wing aircraft are not specifically modeled. |
| BBS | Less than 40 for a battalion size scenario. | yes | Now | yes | yes |
| STOW | Requires more operators than a BBS exercise. | N/A | Now | yes | |
| ModSAF | Dependent on skill level of operators and the scenario. Minimally trained operators can manage about 70 icons, skilled operators can manage about 200 icons effectively. Workstation with aircraft may require more intensive interaction with the units, thus fewer entities can be played on these workstations. | yes | Now | Has platform ID but does not have platform destruction by ID. | yes |
| CBS | Core level exercise uses about 90 - 100 workstations. Up to six operators per workstation. | yes | Now | yes | yes |

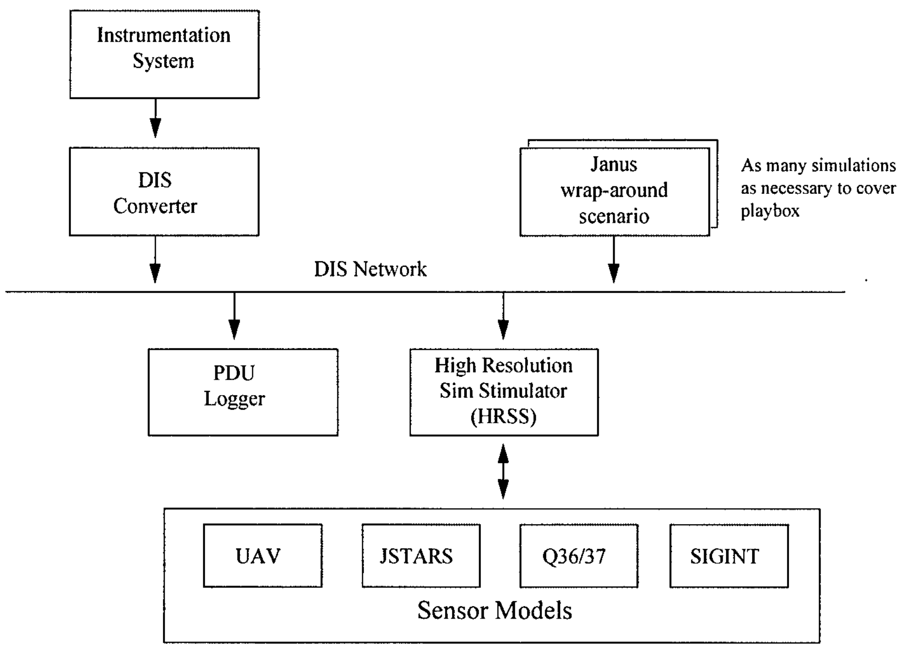
# CSTAR
## CONSTRUCTIVE SIMULATION MATRIX

| | Individual Soldiers | Set view fans | Scenarios run unattended 24 Hrs. | Resurrect, create and place units on demand | End and checkpoint save | Units / Platforms moving at different speeds & distances |
|---|---|---|---|---|---|---|
| JCATS | yes | yes | yes | Create, remove, and move units during play. Resurrection of units may not be available for version 1.0 | yes | yes |
| JCM | yes | yes | yes | yes | yes | yes |
| JTS | yes | yes | yes | yes | yes | yes |
| Janus | yes | yes | yes | no | yes | yes |
| BBS | Possible, but rarely done. | yes | yes | yes | yes | yes |
| STOW | no | N/A | N/A | N/A | N/A | N/A |
| ModSAF | yes | yes | Yes. (ModSAF has a number of memory leaks that effectively reduce the time the simulation can run to under 24 hours. A least one version has corrected enough of these leaks that it can run over 24 hours. Should see improvements in the future.) | Units can be added and deployed on demand. No resurrection. | yes | yes |
| CBS | Possible, but rarely done. | yes | yes | no | yes | yes |

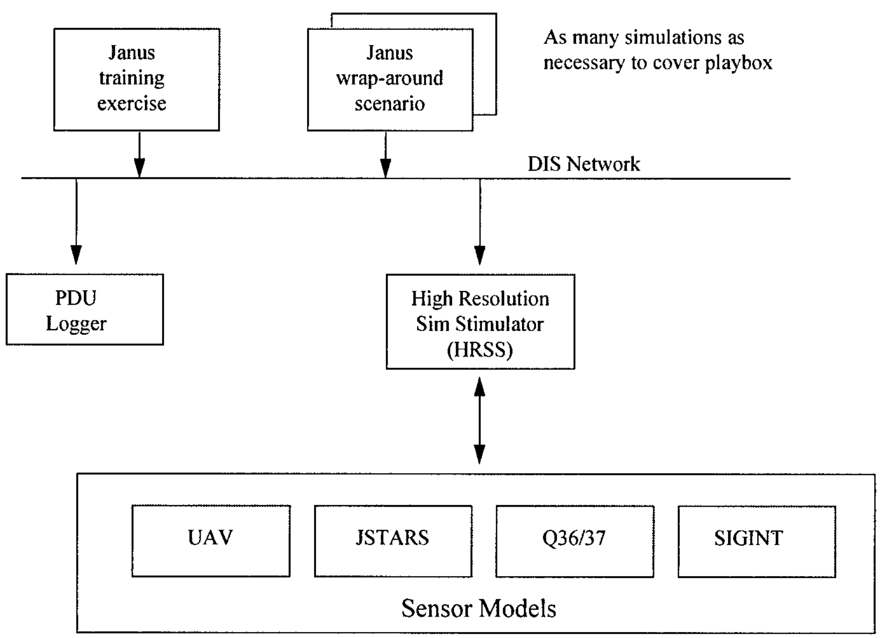
# CSTAR
## CONSTRUCTIVE SIMULATION MATRIX

| | Minimum of 225 weapon systems & signatures | Capture all live NTC play create single virtual scenario | Specific Sensors: JSTARS SIGINT UAV | Hardware Type | Language | Proponent |
|---|---|---|---|---|---|---|
| JCATS | yes | Depends on whether version 1.0 is released with a DIS bridge. If not, it will not be able to capture live data. The following release may have this capability. | yes | Hewlett Packard (HP) 9000 series Unix Workstations (WS). Recommend a C or J class workstation for the server. 715 class workstations is fine for clients. Sun Solaris workstations | C and C++ | JWFC |
| JCM | yes | no | yes | VAX/VMS. DEC Alpha running Open VMS. | FORTRAN | JWFC |
| JTS | yes | no | | HP 9000 Series 700 Unix WS. Sun Solaris. Requires COTS software. | C and C++ | JWFC |
| Janus | 400 system types and 400 weapon types. | Probably not. The CSTTAR test used Janus 6000 only to broadcast the entity state PDUs of Janus entities. No attempt was made to include live entities in Janus. It may be possible to track live movements, firings, and detonations, but not other events. | yes | HP 900 Series 700 Unix WS. Recommend HP C180. | FORTRAN and C | TRAC WSMR |
| BBS | Over 1000 systems. | no | UAV only. | VAX/VMS (MicroVAX 3100). Requires TVs, laser disk player, and PC graphics driver. | Modula2 | NSC |
| STOW | N/A | no | | In addition to the HW required for BBS and ModSAF, A Silicon Graphics, Inc. (SGI) Indigo2 R10000 running IREX 6.2 is required for the Opstate Interpreter (OPSIN). | OPSIN written in C. | STICOM |
| ModSAF | No limit to the number of systems that can be played. | yes | UAV and JSTARS only. | SGI WS; SUN WS; HP 9000 Series 700; DEC Alpha Pentium Pro and Pentium II running Linux | C and C++ | STRICOM |
| CBS | yes | no | no | DEC VAX/VMS minicomputers, primarily a VAX 7620 | SIMSCRIPT | STRICOM |

# APPENDIX B CSTAR CONFIGURATION




Ft. Irwin Live/Constructive Exercise




Ft. Hood Constructive Exercise